

REMARKS

Claims 1-13, 18-22, 24, 28, 30, 31, and 38-42 and are present and active in the application.

C/C composites are considerably stronger and lighter than steel. Such materials increase in strength with increasing heat treatment and resist thermal shock caused by rapid temperature change. However, they suffer from a number of drawbacks including poor oxidation resistance, highly variable wear rates and coefficient of friction, and costly manufacturing. Carbon fibers reinforcing a boron nitride matrix (C/BN composites) have the potential to overcome some of the shortcomings of C/C (Pat. No. 5,399,377), but do not have acceptable heat capacity and thermal conductivity to substitute for C/C composites in aircraft brakes, due to low density. The present invention mitigates this problem.

The present invention is based on the discovery that higher density C/BN composites can be formed when carbon fibers impregnated with borazine oligomers are heated under a pressure exceeding 0.5 MPa. The process of the invention includes: mixing carbon fibers with borazine oligomer, and subjecting the resulting mixture to a first heating. The first heating is at 60 °C to 80 °C, and at a pressure of at least 0.5 MPa, to induce further oligomerization of the borazine without formation of voids (paragraphs [0026]-[0027] of the publication of the present application, US 2005/0106373, emphasis added).

The process can also be applied to carbon fiber preforms. Optimal wear properties are obtained when the preform is subjected to carbon vapor infiltration (CVI) prior to impregnation with the borazine oligomer.

The rejections of the claims under 35 U.S.C. 103 over Economy et al. (US Pat. No. 5,399,377, hereinafter "Economy '377") in view of Mitchell et al. (US Pat. No. 5,112,545) and further in view of Economy et al. (US Pat. No. 4,075,276, hereinafter "Economy '276"), Lavasserie et al. (US Pat. No. 2003/0136502) and Parlier et al. (US Pat. No. 6,284,358) are respectfully traversed. One of ordinary skill in the art would find no reason to modify the method of Economy '377 to produce higher density products by using the process of Mitchell et al. intended to produce a porous preform.

Economy '337 describes borazine oligomer and boron nitride composite materials. Borazine oligomer is prepared by heating borazine at 70 °C (col. 3, lines 13-15). The preparation of the composites is only described in the examples: the oligomeric precursor is impregnated into a fiber bundle, and then the matrix is partially stabilized in shape through further polymerization in the temperature range of 50 °C to 90 °C for two days under a nitrogen atmosphere in an oven (col. 4, lines 24-35). Next, thermal processing is conducted under non-oxidative cross-linking conditions to a final temperature of 400 °C supplied by a Carver hot-press, with molding pressures gradually applied up to 5 ksi (col. 4, lines 38-45). There is no suggestion to apply pressure during the first heating at 50 °C to 90 °C – this heating is carried out in an oven under a nitrogen atmosphere.

Mitchell et al. provides carbon composite articles and preforms for manufacturing the articles. The preforms are prepared at a lower cost by forming them from fibrous materials which are bonded together by small amounts of a carbonaceous binder (col. 1, lines 14-18). The technique of Mitchell et al. employs extremely small amounts of binder (as low as 0.5% to 15% by weight) to selectively bond the individual fibers together at multiple sites while avoiding total encapsulation of any individual fiber, thus obtaining a highly porous mass (col. 2, lines 43-52). The binder is applied to the carbon fibrous material by hand sprinkling, through use of a roller brush, by surface spraying, or by other similar means (col. 7, lines 17-22). Next, the fibrous material is subjected to heating under pressure: during this step the individual fibers are selectively bonded together by the binder at multiple sites, yielding a “shaped substrate” (col. 7, lines 22-32). Finally, the shaped preform is subjected to carbon vapor deposition (col. 7, lines 33-37) on and between the nonencapsulated substrate fibers (col. 3, lines 35-41; col. 9, lines 16-21), yielding C/C composites. Because of the small quantity of binder, the need for a resin carbonization step is eliminated (col. 3, lines 7-12).

In Example 1 of Mitchell et al., a resin solvent mixture was sprayed on binder material disks. The disks were cut into segments which were compressed at a pressure of 350 PSI. The temperature was maintained between 250 °F and 350 °F (col. 9, line 48 to col. 10, line 20). Rigidized preforms were obtained (col. 10, lines 21-22). The preforms were then subjected to CVD, resulting in the final product (col. 9, line 48 to col.

10, line 52). The only description of using pressure is to form a porous substrate or preform before forming the composite.

Economy '276 discloses processes for manufacturing boron nitride. Such processes however, do not have borazine as starting material or feature a heating under pressure step. Parlier et al. teaches the manufacturing of textile preforms sheathed in a boron nitride coating having a microporous granular structure, but is silent regarding heating a mixture of borazine and fibers under pressure. Lavasserie et al. discloses the manufacturing of composite material parts by making needled preforms in which a powder of resin and/or solid fillers is incorporated, and densifying the preforms (pars. [0041] – [0047]), but is also silent as to heating a borazine mixture under pressure.

The only heating under pressure of Mitchell et al. is directed to the formation of a porous preform with a carbonaceous binder, not formation of a final dense composite. In contrast, the first heating of Economy '377 is the first part of forming a dense composite from borazine oligomer impregnated into a fiber bundle. One of ordinary skill in the art would find no reason to modify the method of Economy '377, which forms a dense composite, by using the process of Mitchell et al. intended to form a porous preform. The present invention is therefore not obvious in view of the cited references, and removal of these grounds of rejection is respectfully requested.

The present invention is further distinguished from the cited references because the results achieved would not be predictable in view of the references. The fact that references can be combined or modified may not be sufficient to establish prima facie obviousness: “The mere fact that references can be combined or modified does not render the resultant combination obvious unless the results would have been predictable to one of ordinary skill in the art.” M.P.E.P. § 2143.01 (III), citing KSR International Co. v. Teleflex Inc., 550 U.S. ___, ___, 82 USPQ2d 1385, 1396 (2007).

The pressure ranges applied by Mitchell et al. are applied to form porous preforms with a carbonaceous binder; no borazine oligomers are present. Also, none of the other references describes heating borazine oligomer initially under pressure. Unless a reaction is carried out, there is no way of predicting changes in density, where the composition and crystal structure do not change. The higher densities of the boron

nitride composites achieved by the present invention are thus unpredictable in view of the cited references.

Applicants submit that the present application is now in condition for allowance. Early notice of such action is earnestly solicited.

Respectfully submitted,



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